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# Volar Locking Plate versus External Fixation for Displaced Intra-Articular Distal Radius Fractures: A Prospective Randomized Comparative Study of the Radiological Parameters and Functional Outcomes

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**Abstract:** ***Background: The objective of the study was to compare the efficacy of external fixation and volar plating on the Radiological (Radial length, Radial inclination and volar tilt) and functional parameter (QUICK DASH score) of completely articular (AO 23 C1, 23 C2, 23 C3) distal end radius fractures. Materials and methods: This prospective randomized study comprised 27 patients treated with external fixation and 33 patients treated with volar locking plates. The patients were followed up at 6 weeks, 12 weeks and 6 months after surgery. At the time of follow up the radiological parameters and Q-DASH scores were assessed. Results: At 6 months after surgery, we observed volar locking plate patients showed better results than external fixator patients with respect to both radiological parameters and functional status. Both volar tilt (External fixation, 11.37 ± 1.47; Volar plate, 12.12 ± 1.34) and radial inclination (External fixation, 22.26 ± 1.63; Volar plate, 23.27 ± 0.72) showed statistically significant difference in-betweenboth the groups. Although radial length was not statistically significant. Again QUICK Dash score (External fixation, 9.71 ± 3.55; volar plating, 6.80 ± 0.46) also showed statistically significant difference. Conclusion: Volar locking plate is superior in comparison to external fixation in cases of completely intra articular distal radius fractures.***

**Keywords:** Distal radius fracture, JESS, K-Wire, Volar locking plate

## 1. Introduction

Distal radius fractures are most common fractures of upper limb presenting at emergency rooms, compromising of more than 18% of all fractures [1]. Distal radial fractures have a bimodal type of age distribution with high-energy trauma contributing in younger and low energy trauma in elderly population. Females are more liable to distal radius fractures when compared with males mainly because of more severe osteoporosis and a higher liability of elderly women to falls [2, 3] compared to the age-matched men. [2]

The management of these fractures has evolved over the preceding twenty years from universal cast treatment to neutralization with a bridging external fixator and finally replaced by volar buttress plating. The primary goal of treatment of these fractures is restoration of wrist function. Good functional outcome requires restoration of the disrupted radial anatomy, maintenance of accurate and stable reduction and early hand mobilisation to reduce oedema and pain. The Joshi External Stabilising System (JESS) / External fixator has been used for bone stabilisation in the Indian subcontinent for 30 years. It was initially used in hand surgery. As the construct was simple, light weight and could be easily manoeuvred it was also useful in treating contractures of the hand and wrist and interphalangeal joint due to burns and due to diseases like leprosy. It assists the surgeon in obtaining fracture stabilisation and helps in fracture healing by gradual and controlled distraction and works on the principle of ligamentotaxis. [4]

## 2. Materials and Methods

This study was designed to analyse and compare the functional and radiographic outcome in distal radius fractures of 60 post-menopausal women treated by closed reduction through JESS augmented with K-wires and volar-locking plating done in our department of Orthopaedics Surgery NRS Medical College and Hospital over a period of 1 year and 5 months from Jan 2019 to May 2020. During this period, fractures of distal radius in post-menopausal patients were managed primarily by internal fixation with Locking compression plate or JESS augmented with K-wires. Study population chosen was post-menopausal women with distal radius fracture attending our orthopaedics OPD and emergency meeting all our including criterion. The design of our study was Interventional prospective randomized control trial study**.** Sample size was calculated

based on previous studies. With the power at 80% and 5% level of significance, calculation has done using the formula [5],

$n= 2 (Z \alpha/2 +Z \beta) 2 *\sigma 2 /E 2$

Where,

n= Sample Size

Z α/2 (two-tailed) = Level of significance (α = 95%=1.96)

Z β = Desired power (β =20%=0.8416)

σ = Standard deviation (σ =1.00)

E =Effect Size (E=0.760)

At 95% significance level with 80% power value, the sample size for individual group was 25.6. Adding 5% as wasting factor =The minimum sample size required 25.6 +1.28=26.88. So, current study was undertaken with a round up sample size of 60 for two groups combined. (Group H-27; group O-33)

The inclusion criteria were post-menopausal women willing to sign in informed consent and ready to attend for follow up. The fractures chosen were distal radius completely intra articular fractures (AO Classification 23 C1, 23 C2 and 23 C3). The excluding criteria were menstruating women, unfit for operation and G. A type 3 fracture. The statistical software SPSS version 20 and Excel 2016 were used for the analysis. Procedure of the data analysis was processed through Preliminary data inspection, content analysis and interpretation. Continuous variables measurement was expressed as Mean ± Standard Deviation and Intergroup Comparison by One-way ANOVA at 0.05 level of significance. The categorical variables like age, sex and side were expressed by number of patients and the variable significant level was identified using Pearson's Chi Square test at 0.05 level of significance. The following Statistical formulas were used [5] mean, standard deviation, Pearson chi-square test, one-way anova and level of significance.

Surgical steps for group O

Patient made supine with hand positioned in supine manner by assistant on hand support. Antiseptic dressing protocol strictly followed and draping done. Closed manipulation always attempted first to make reduction easier by the principle of ligamentotaxis. The skin is incised longitudinally along the course of the flexor carpi radialis (FCR) tendon. The FCR sheath is opened and the tendon retracted to the ulnar side. Great care must be taken to avoid pressure on the median nerve. Underneath the FCR sheath lies the flexor pollicislongus muscle. It must be released and retracted ulnarly, by finger dissection revealing the pronator quadratusmuscle. The pronator quadratus muscle is elevated from its radial origin proximally and the incision turned in an L-shaped fashion distally. The horizontal limb is placed at the fibrous transition zone between pronator quadratus and the watershed line. This fibrous zone lies a few millimetres proximal to the watershed line and is sharply elevated from the bone to expose the fracture lines and palmar fragments. The position of the joint line can be determined with a hypodermic needle placed inside the joint. The watershed line represents the margin between the structures which are elevated proximally and the palmar wrist extrinsic ligaments. They should not be detached from the radius (to expose the joint surface) as this may destabilize the wrist. Reduction done in fracture specific manoeuvres and can be fixed temporarily with k-wires after checking it under C-arm. Fixation with a plate should start on the ulnar side of the radius. The screw position in the ulnar corner of the radius should be verified under image intensification to prevent penetration of the radiocarpal, DRUJ, or dorsal cortex. After plate fixation, thorough N. S. given. Wound closed, dressing done compression bandage applied and tourniquet removed. Distal pulse confirmed and below elbow POP slab applied.

Surgical steps for group H

Manipulation with traction and counter traction applied. In shake hand of the wrist and wrist manipulated using three-point bending principle. Reduction checked under c-arm.10cm proximal to the radial styloid is identifiedcan also be at least 5cm outside the zone of injury bare area that is located in the palpable interval between thebrachioradialis and the ECRL muscles. Small incisions at pin sites made. With caution to protect the branches of the superficial radial and lateral antebrachial cutaneous nerves as damage to these nerves can cause a painful neuroma. Proximal pins at a 45-degree angle to the long axis of the arm are placed. Pins placed in the dorsal radial to ulnar volar direction. The periosteum is seen. Holes are drilled and half pins are placed. A fixator clamp is used after the placement of the first half pin to determine the placement of the second half pin. The placement and depth of the pins checked with fluoroscopy. The bare area is palpated between the first dorsal interosseous muscle and the extensor tendon of the index finger. Both pins placed in the proximal 60% of the metacarpal, this is to avoid encroaching on the metacarpophalangeal joint capsule. The 3 mm half pins placed in the centre of the metacarpal shaft and fixator clamp inserted to guide the placement of the distal pin. Pin to rod connectors applied. Clamps placed one fingerbreadth away from skin. No blockage of thumb and wrist motion are confirmed. Rodconnected proximally first and then the rod is secured distally. Reduction checked with fluoroscopy. Hand tight clamps in place. Fracture stability augmented by 1.5 mm k wires (fracture specific). A final tightening performed. Pin site dressing is done.

Active finger movement is encouraged when the effect of brachial block fades away. In case of Group O wrist mobilization is also encouraged from 24 hours.

Follow up-

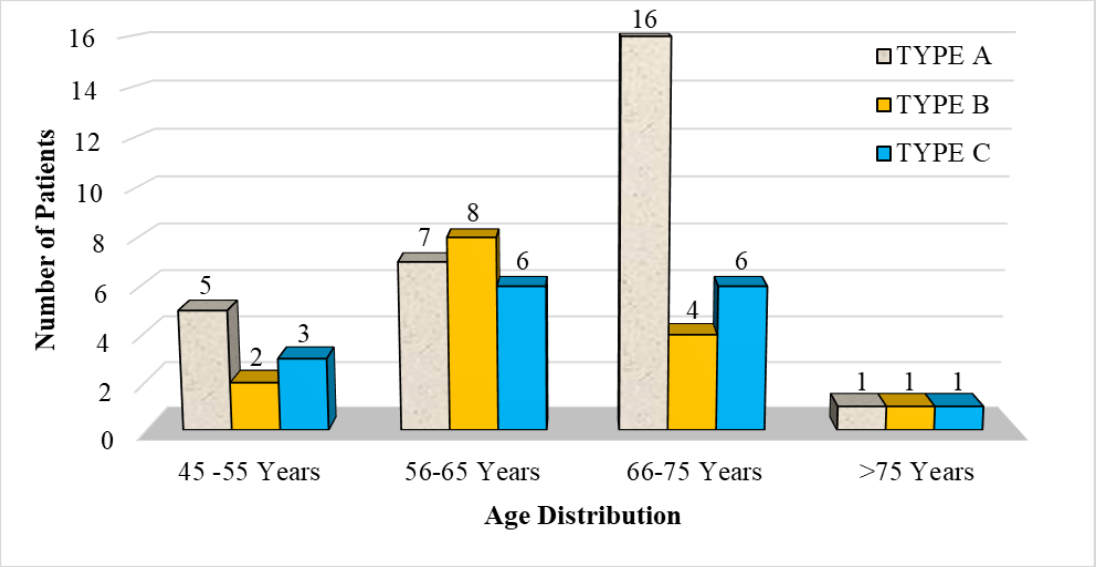
Radiological parameters were measured at every 6th, 12th, 24thweek and 1 year for comparison and fracture healing was noted. Functional outcomes were measured by comparing by QUICK DASHscore.

## 3. Result and Analysis

**1) Table –Age Distribution**

| Age (in years) | Type A (Percentage) | Type B (Percentage) | Type C (Percentage) | Total (Percentage) | P Value | Statistical Significance |
|---|---|---|---|---|---|---|
| 45-55 | 5 (8.33%) | 2 (3.33%) | 3 (5%) | 10 (16.67%) | 0.558 | No Significant Differences |
| 56-65 | 7 (11.67%) | 8 (13.33%) | 6 (10%) | 21 (35%) | | |
| 66-75 | 16 (26.67%) | 4 (6.67%) | 6 (10%) | 26 (43.33%) | | |
| >75 | 1 (1.67%) | 1 (1.67%) | 1 (1.67%) | 3 (5%) | | |
| Total (Percentage) | 29 (48.33%) | 15 (25%) | 16 (26.67%) | 60 (100%) | | |

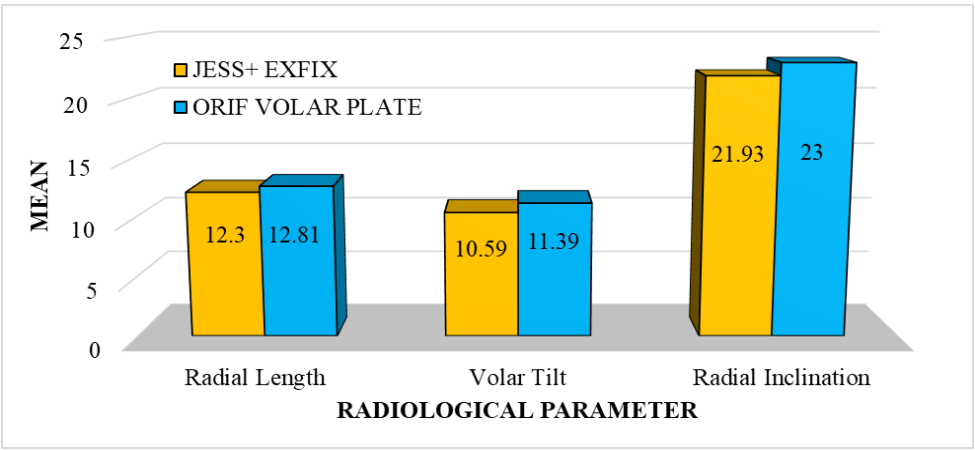
In this study, age has classified into four categories.10 patients (16.67%) belong to the age group 45-55 years.21 patients (35%) belong to the age group 56-65 years.26 patients (43.33%) under the 66-75 age group and 3 patients (5%) found in more than 75 age group. In Table 1, create distribution between age group and irrespective of treatment modality. There was no statistically significant difference between them using Pearson chi-square test (***p value is 0.558***) at 0.05 levels of significance.




**2) Comparison of Radiological Parameter for all Fractures at 6wks**

| Radiological Parameter | JESS + EXFIX Mean ± Std. Dev. | ORIF VOLAR PLATE Mean ± Std. Dev | P VALUE | Statistical Significance |
|---|---|---|---|---|
| Radial Length | 12.30 ± 1.10 | 12.81 ± 1.42 | 0.124 | No Significant Differences |
| Volar Tilt | 10.59 ± 1.05 | 11.39 ± 1.68 | 0.35 | No Significant Differences |
| Radial Inclination | 21.93 ± 1.44 | 23.00 ± 0.87 | 0.001 | Significant Differences |

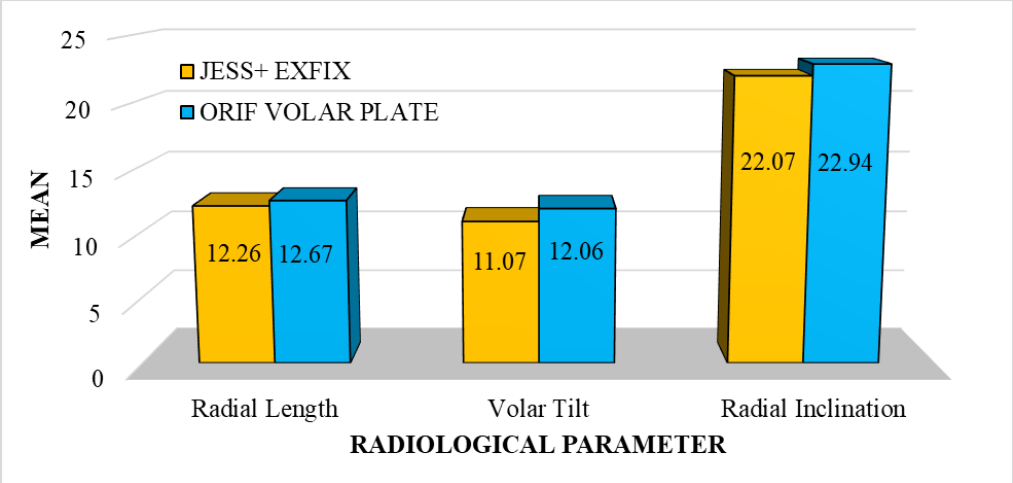
Table 6 introduced a comparison study between Radiological Parameters (Wrist at 6 weeks) and different types of treatment. A comparison has done using a parametric test (One-way ANOVA). Radial length and Volar Tilt do not have significant effect on the different types of treatment (***p value respectively 0.124 and 0.35***). Radial Inclination creates statistically significant differences between the two ways of treatment (***p value 0.001***).



### 3) Comparison of Radiological Parameter for all Fractures at 12wks

| Radiological Parameter | JESS + EXFIX Mean ± Std. Dev. | ORIF VOLAR PLATE Mean ± Std. Dev | P VALUE | Statistical Significance |
|---|---|---|---|---|
| Radial Length | 12.26 ± 1.06 | 12.67 ± 1.29 | 0.193 | No Significant Differences |
| Volar Tilt | 11.07 ± 1.30 | 12.06 ± 1.34 | 0.006 | Significant Differences |
| Radial Inclination | 22.07 ± 1.54 | 22.94 ± 0.83 | 0.007 | Significant Differences |

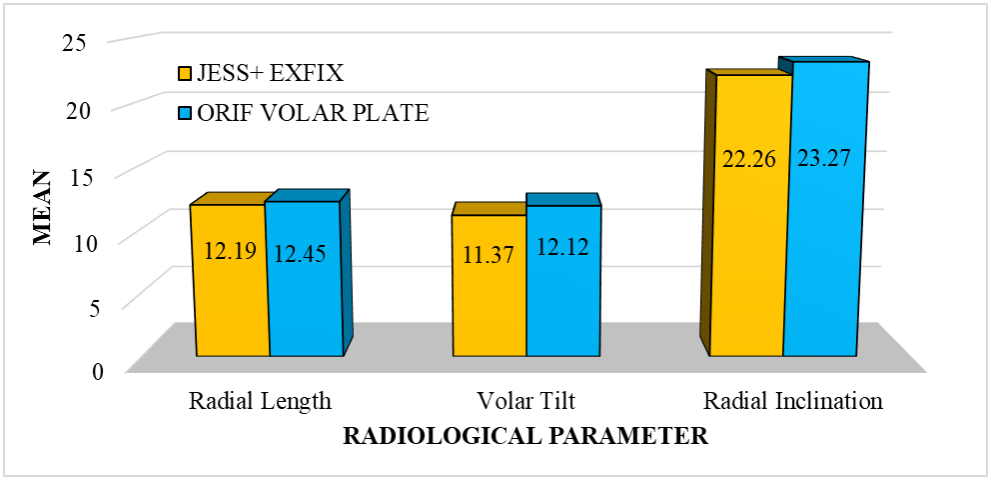
Table 7 introduced a comparison study between Radiological Parameters (Wrist at 12 weeks) and different types of treatment. A comparison has done using a parametric test (One way ANOVA). Volar Tilt and Radial Inclination have significant effect on the different types of treatment (***p value respectively 0.006 and 0.007***). Radial length does not have statistically significant differences between the two ways of treatment (***p value 0.193***).




### 4) Comparison of Radiological Parameter of all Fractures at 24 Wks

| Radiological Parameter | JESS + EXFIX Mean ± Std. Dev. | ORIF Volar Plate Mean ± Std. Dev | P Value | Statistical Significance |
|---|---|---|---|---|
| Radial Length | 12.19 ± 1.00 | 12.45 ± 1.12 | 0.335 | No Significant Differences |
| Volar Tilt | 11.37 ± 1.47 | 12.12 ± 1.34 | 0.043 | Significant Differences |
| Radial Inclination | 22.26 ± 1.63 | 23.27 ± 0.72 | 0.002 | Significant Differences |

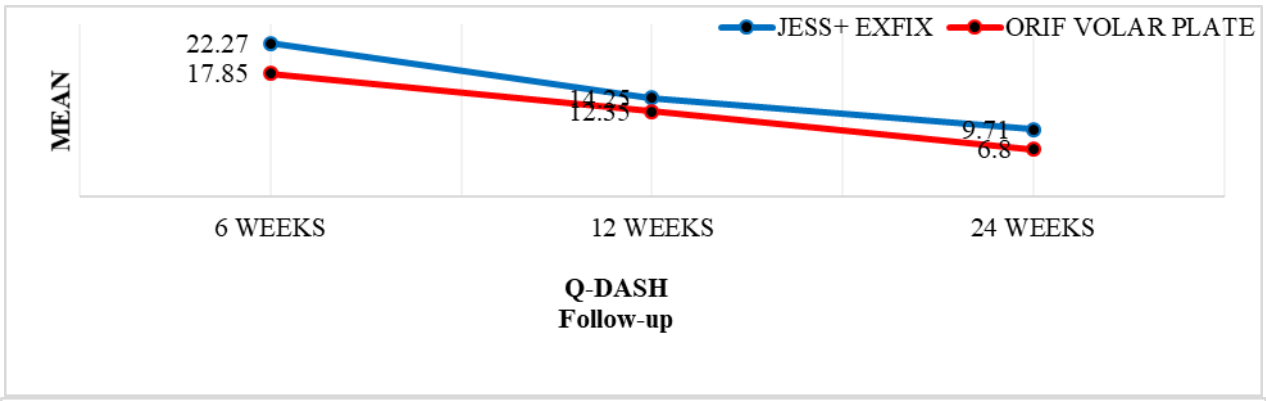
Table 8 introduced a comparison study between Radiological Parameters (Wrist at 24 weeks) and different types of treatment. A comparison has done using a parametric test (One way ANOVA). Volar Tilt and Radial Inclination have significant effect on the different types of treatment (***p value respectively 0.043 and 0.002***). Radial length does not have a statistical significant difference between the two ways of treatment (***p value 0.335***).

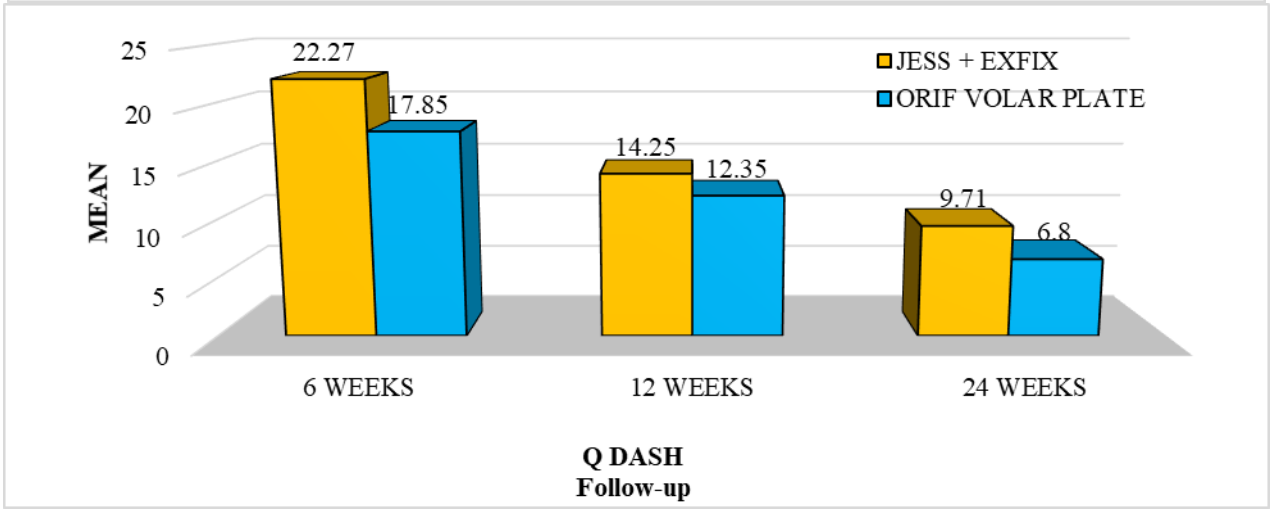



### 5) Q-Dash Scores

| Follow up | JESS + EXFIX Mean ± Std. Dev. | ORIF VOLAR PLATE Mean ± Std. Dev. | P Value | Statistical Significance |
|---|---|---|---|---|
| At 6wks | 22.27 ± 2.60 | 17.85 ± 2.33 | .001 | Significant Differences |
| At 12wks | 14.25 ± 2.79 | 12.35 ± 1.09 | .001 | Significant Differences |
| At 24 Wks | 9.71 ± 3.55 | 6.80 ± 0.46 | .001 | Significant Differences |

Table 21, identified a comparison of Q-DASH score follow-up (6 weeks, 12 weeks and 24 weeks) over two groups (JESS + EXFIX and ORIF VOLAR PLATE). A comparison has done using a parametric test (One-way ANOVA). Each category of follow up weeks have significant effect on JESS + EXFIX and ORIF VOLAR PLATE at 5% level of significant.




## 4. Discussions

Distal radius fractures are very common fragility fractures among post-menopausal women. The aim of the study is to study and compare the outcome of two most commonly used surgical method of treating the problem. We studied all radiological parameter one by one and recorded it for both the group in every follow up.

We also calculated their functional outcome based on QDASH score. The purpose of this study is to study the anatomical and functional outcome of distal radius fracture.

The data collected in this study is assessed, analysed and compared with the other studies and the results were evaluated.

In our study we found at 6 weeks volar tilt had significant difference in-between the two groups. But at 12 weeks and 24 weeks both volar tilt and radial inclination was significantly different in-between the two groups. Radial length was not significantly different in-between the two groups the reason may be due to the fact that it is maintained due to distraction and ligamentotaxis in external fixator group but the other two parameters were not maintained with external fixator. Again Q-Dash score

*Comparison tables with previous studies:*

**Volar Tilt**

Comparing final volar tilt of our study with recent studies conducted.

| Study | Year | Volar Tilt (Open reduction and internal fixation) | Volar Tilt (EXFIX) |
|---|---|---|---|
| Rizo et al[7] | 2007 | 11 | 3 |
| Zenke et al[8] | 2011 | 12.2 | 10.7 |
| Musa et al[11] | 2018 | 6.15 | 11.5 |
| Zhou et al[12] | 2019 | 10 | - |
| Sp gill et al[15] | 2019 | 12 | 11 |
| Bobade et al[16] | 2019 | 4.08 | 6.48 |
| Present study | 2020 | 12.12 | 11.37 |

**Radial Length**

Comparing our result of radial length with recent study:

| Study | Year | Radial Length With (Open reduction and internal fixation) | Radial Length With Exfix |
|---|---|---|---|
| Aditya et al[9] | 2016 | 12 | 11.1 |
| Zhou et al[12] | 2019 | 10.7 | 10.4 |
| Xiafaiyu et al[13] | 2019 | 10.4 | 10.8 |
| Cieckeli et al[14] | 2019 | 11.1 | 11.0 |
| Bobade et al[16] | 2019 | 12.16 | 11.28 |
| Present study | 2020 | 12.45 | 12.19 |

Hence, our study is strongly corroborative with the findings of recent studies.

**Radial Inclination**

| Study | Year | Radial Inclination (Open reduction and internal fixation) | Radial Inclination (EXFIX) |
|---|---|---|---|
| Aditya et al[9] | 2016 | 17.9 | 16.9 |
| Zhou et al[12] | 2019 | 22.6 | 21.4 |
| Xiafaiyu et al[13] | 2019 | 22.2 | 20.8 |
| Cieckili et al[14] | 2019 | 19.1 | 19.3 |
| Present study | 2020 | 23.27 | 22.26 |

Hence, our study is strongly corroborative with the findings of recent studies.

**Quick Dash Score**

Comparing the mean value of QDASH score with recent studies we got

| Study | Year | QDASH score for (Open reduction and internal fixation) | QDASH score for EXFIX |
|---|---|---|---|
| Rizzo et al[7] | 2007 | 9 | 23 |
| Dash et al[10] | 2017 | 12.9 | 18.9 |
| Xiafaiyu et al[70] | 2019 | 7.9 | 11 |
| SPS Gill et al[72] | 2019 | 6 | 10 |
| Present study | 2020 | 6.8 | 9.71 |

Thus, our finding is roughly corroborative with the recent studies.

Thus, from the findings we found we can conclude that in cases of Open reduction and internal fixation with volar locking plate in completely articular distal radius intra articular fracture gives better result radiologically and functionally than cases where JESS is performed.

**Figure 1:** Showing pre operative and post operative radiograph at 6 weeks in a case where volar locking plating was done

**Figure 2:** Showing pre and post operative radiograph in a patient treated with JESS and K-wire at 6 weeks (after removal of JESS and K-Wire)

## 5. Conflict of Interest

The authors bear no conflict of interest

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